Abstract

Arsenic has recently become a matter of great concern due to the increased knowledge of its toxicological and carcinogenic effects on human health, causing the guideline value to be lowered from 100 µg/L to 50 µg/L and further to 10 µg/L by WHO (World Health Organization). As the source of arsenic is the Himalayan mountain and the Tibet Plateau, the flood plains of all the rivers that originated from those sources are expected to be arsenic contaminated. It is anticipated that, the groundwater As contamination is from the deposition of newer alluvium (Holocene) sediment. Groundwater of Majuli island in Assam on this basis is expected to be arsenic contaminated. Therefore, in the present study an attempt has been made to gain an understanding about the As contamination status and the health risk of the people in Majuli- the largest river island of the Brahmaputra, Assam by investigating the water and sediment chemistry as well as the urine, hair and nail of the people who are drinking arsenic contaminated water. The subsequent removal study of arsenic from highly contaminated water of Majuli island has also been undertaken in the study.

In the present study, surveys have been conducted in Majuli to understand the magnitude of contamination. Total 380 tube-well water samples were analyzed for arsenic (by FI-HG-AAS). Of the total groundwater samples analyzed, 37.6 % of samples exceeded 10 µg/L (WHO limit), 14% contained >50 µg/L (maximum arsenic concentration recorded was 468 µg/L). The relation between the depth of the tubewell and arsenic concentration has also been studied. Depth information of 303 tubewells from the Majuli island out of 380 analyzed samples, 77% of those tubewells are shallow tubewells in the depth range up to 15 m and it appears that in the Majuli island arsenic concentration gradually decreased beyond 25 m depth with few exceptions. Tube-well water samples were also analyzed for iron (n=319) and found elevated iron content (minimum=36 µg/L and maximum=22000). The correlation between iron and arsenic is poor (r = 0.23).

Bore hole sediment samples were collected from different depths during tube well installation at 7 locations. Sediment samples were digested for arsenic analysis using
microwave digestion technique and measured by FI-HG-AAS. The arsenic concentration ranged from 0.36 mg/Kg to 1.44 mg/Kg. The arsenic concentration did not show any correlation with depth.

To know the present arsenic body burden to population in Majuli 114 biological samples (40 hair, 33 nail, and 41 urine) have been collected and analyzed from the arsenic affected villages. The arsenic concentrations of urine (max = 697.5 µg/l), hair (max = 5461 µg/kg) and nail (max = 11725 µg/kg) correlated significantly, with drinking water arsenic concentrations.

Increasingly stringent legislation on the permissible concentrations of arsenic in drinking water has led to increased investigations of the removal of arsenic from drinking water. Hence, this study also addresses the water treatment approach and focuses on developing a novel arsenic removal technology that uses the surface functionalized ultrafine iron oxide nanoparticles as a new sorbent. The experiments carried out during this study address the removal of both arsenate and arsenite using surface functionalized ultrafine iron oxide nanoparticles developed through a gentle chemistry route. The nanoparticles are used under a wide range of experimental conditions and it is found that surface functionalized ultrafine iron oxide nanoparticles can absolutely remove arsenic from arsenic contaminated water. The efficiency of arsenic removal has been drastically improved by considering nanoparticles of size 10 nm and subsequent surface engineering of the nanoparticles resulting more adsorption sites being exposed to arsenic. The mechanism for adsorption was identified through electron microscopic and spectroscopic studies. The removal of As from water (synthetic water and natural groundwater) using surface functionalized ultrafine oxide nanoparticles is sensitive to several parameters tested, including pH, contact time, adsorbent dosage, initial arsenic concentration and the source water composition. The mechanism for high adsorption efficiency is attributed to surface conjugation of functionalized ultrafine Fe₂O₃ nanoparticles with arsenic. Equilibrium isotherms and the adsorption kinetics of arsenic onto the surface functionalized ultrafine iron oxide nanoparticles were studied experimentally for both the natural groundwater and the artificial model water in a batch system. The resulting isotherms were fitted using the Langmuir and Freundlich models and the parameters of
the equation were determined. Simplified models such as pseudo-first order and pseudo-second-order models were applied to study the kinetics of adsorption. Finally, the simultaneous separation of arsenic sorbed nanoparticles was ensured by entrapping them in hydrophilic calcium alginate beads and thereby a pure arsenic free solution has been obtained.